Research Roadmaps for Concrete Civil Structures

Light Water Reactor Sustainability R&D Program

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MEETING BETWEEN THE U.S. NUCLEAR REGULATORY COMMISSION STAFF AND INDUSTRY TO DISCUSS SUBSEQUENT LICENSE RENEWAL
Concrete and Civil Structures
December 5, 2013

The DOE-NE Light Water Reactor Sustainability Program is supporting subsequent license extension decisions

Vision

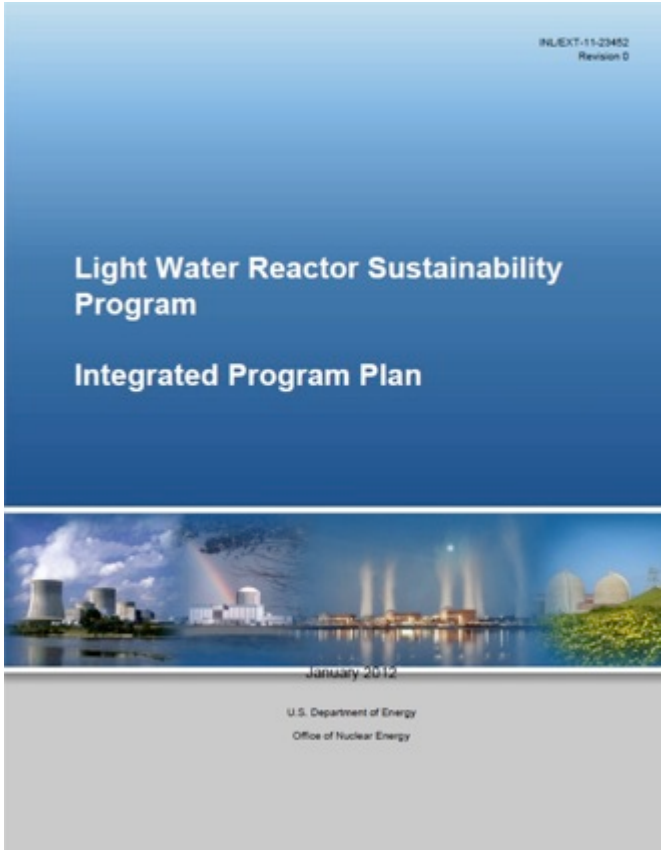
- *Enable existing nuclear power plants to safely provide clean and affordable electricity beyond current license periods (beyond 60 years)*

Program Goals

- Develop fundamental scientific basis to understand, predict, and measure changes in materials as they age in reactor environments
- Apply this knowledge to develop methods and technologies that support safe and economical long-term operation of existing plants
- Research new technologies that enhance plant performance, economics, and safety

Scope

- Materials Aging and Degradation
- Advanced Instrumentation and Controls
- Risk-Informed Safety Margin Characterization



More information and recent reports are available on

www.inl.gov/lwrs

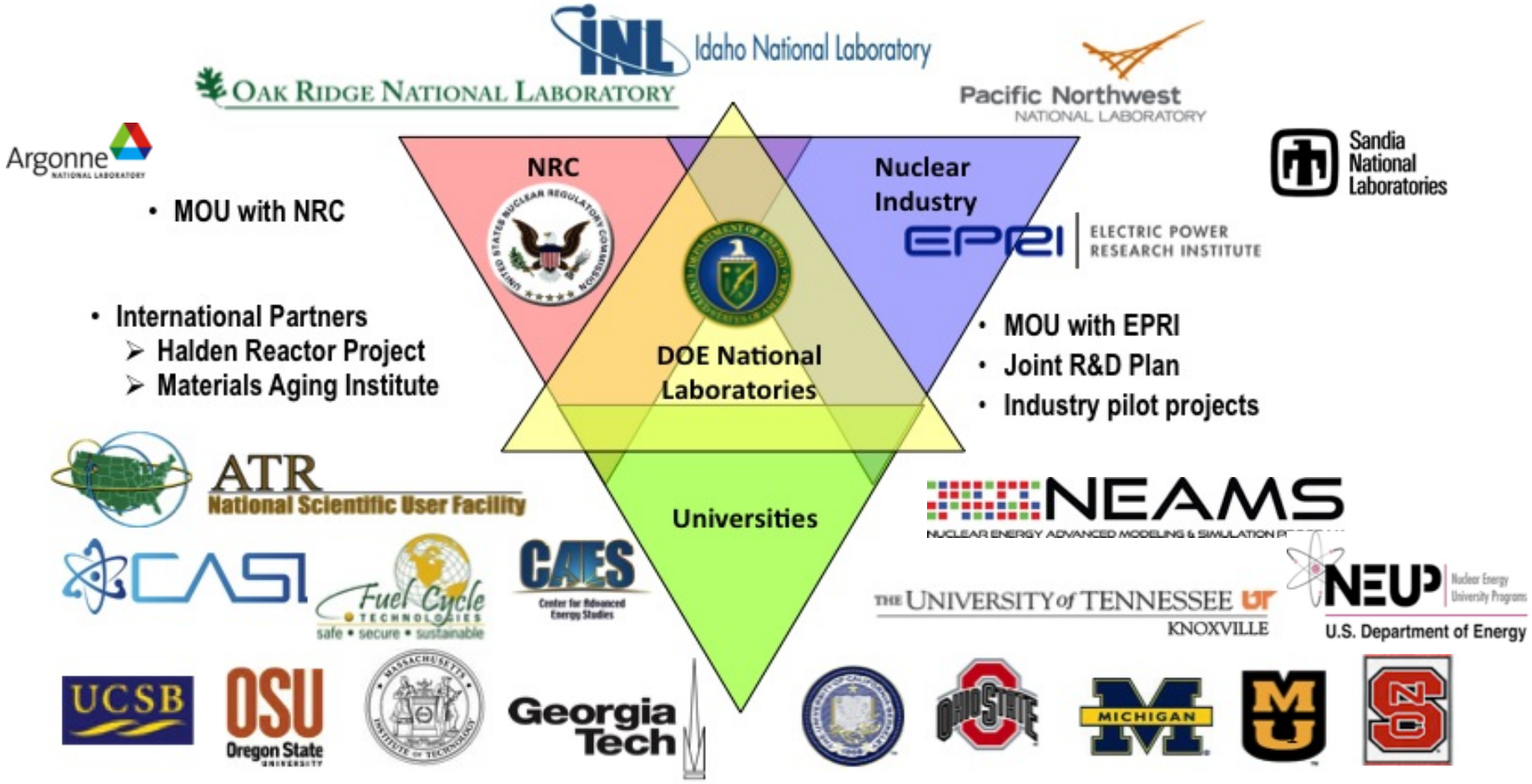
LWRS Light Water Reactor Sustainability

EPRI ELECTRIC POWER RESEARCH INSTITUTE

LWRS research in materials aging and degradation areas provide results in several ways

- **Measurements of degradation**: High quality data will provide key information for mechanistic studies, but has value to regulators and industry on its own.
- **Mechanisms of degradation:** Basic research to understand the underlying mechanisms of selected degradation modes will lead to better prediction and mitigation.
- **Modeling and simulation:** Improved modeling and simulation efforts have great potential in reducing the experimental burden for life extension studies. These methods can help interpolate and extrapolate data trends for extended life.
- **Monitoring:** While understanding and predicting failures are extremely valuable tools for the management of reactor components, non-destructive monitoring must also be utilized.
- **Mitigation strategies:** While some forms of degradation have been well-researched, there are few options in mitigating their effects. New technologies may overcome limits of degradation in key components and systems.

The LWRS program has a diverse set of partners



Objectives: October Meeting at ORNL

- Develop an assessment of concrete R&D to support implementation of Aging Management Programs (AMPs) and other actions for safe Long-Term Operation (LTO).
  - Review current state of knowledge and R&D project plans
  - Develop initial consensus on R&D needs for concrete aging management
  - Establish a roadmap with timelines for conducting R&D efforts
- Refine cross organization coordination to achieve roadmap execution success

Concrete R&D Needs Assessment

- Identified Concrete Issue Areas in the EPRI LTO Issue Tracking Table (ITT)
  - Table items jointly developed with industry, DOE and other stakeholder participation
    - Specific references to EPRI and DOE (LWRS) R&D efforts
  - Provide initial basis for R&D project need and prioritization to support utility decisions on long-term operations
- Concrete issues (irradiation and ASR) also highlighted in recent Aging Management Program R&D Assessment
  - Category 1 items involve R&D to better characterize and manage 60 to 80 years materials performance

ITT Concrete Issues

Issue ID (New)	Issue ID (Old)	Primary Issue Description	Sub-issue Description	Detailed Description	EPRI LTO Status	EPRI Program (Other)	DOE-LWRS	IMT Gap or MDM Cell	Category	AMP	Comments
10	2.1	Concrete and Concrete Aging	Concrete issues identification	Concrete issues identification, prioritization from operating experience, expert elicitation, and consideration of experience and analysis from other industries.	LTO	NDE	DOE LWRS		B		
11	2.1	Concrete and Concrete Aging	Concrete issues resolution, guidelines and analysis tools	Concrete issues resolution guidelines and analysis tools- Examples are ASR testing and inspections techniques and boric acid degradation on the SFP concrete and rebar.	LTO	NDE	DOE LWRS		B		
12	2.2	Concrete and Concrete Aging	Pilot study of concrete cracking of fuel pools at liner connections	Pilot study of concrete cracking of fuel pools at liner connections. The issue is corrosion of metal reinforcement from boric acid.	LTO Co-funded with MAI	NDE			B		Long-term R&D to support continued improvement of the basis for the AMPs
13	2.2	Concrete and Concrete Aging	Evaluation of concrete structures subject to external stressors (radiation, temperature, corrosion)	Concrete exposed to external stressors may age at an accelerated rate. Research should be conducted to determine if the rate of degradation will cause an issue in developing the technical basis for LTO. Examples include radiation and temperature damage to the reactor cavity and chloride attack of cooling towers.	LTO	NDE	DOE LWRS		B		Long-term R&D to support continued improvement of the basis for the AMPs

EPRI Issue Tracking Table Background

LTO Issue Tracking Table

LEGEND
Active on-going work
Planned work
No planned work; potential scope
Not within LTO scope
Complete

The purpose of the Long Term Operations Issue Tracking Table (ITT) is to identify and prioritize the R&D projects needed to support safe, reliable and economic long-term operations. The ITT is the result of an expert solicitation process and is maintained as a living document. It is reviewed on an annual basis by stakeholders from EPRI, NEI, DOE, National Labs and EPRI utility advisors to ensure accuracy and completeness. The R&D projects are colored coded to indicate status of the supporting R&D projects, and assigned a Category. The Categories are:

A – An Industry developed program *or* R&D results are needed for a utility to submit an application for SLR to the NRC.

B- These are R&D projects to support the technical basis for the aging management programs. Sufficient information exists to submit a SLR application, but continued R&D projects are needed to provide informed insights for aging management, inspection intervals and repair/replacement decisions

C-These projects are not needed for SLR, but support long-term sustainability based on addressing obsolescence and economic improvements for extended operations

The EPRI-LTO and the DOE LWRS Program use the ITT to ensure the necessary R&D projects being performed at the right time to support of long-term operations for the NPPs owners and operators.

Concrete R&D Current Status

- EPRI/DOE (LWRSP) Joint R&D Plan (April 2013)
  - Identifies concrete issues as a collaborative effort
  - Lists an initial number of projects
- EPRI Nuclear Concrete Structures Aging Reference Manual (2011)

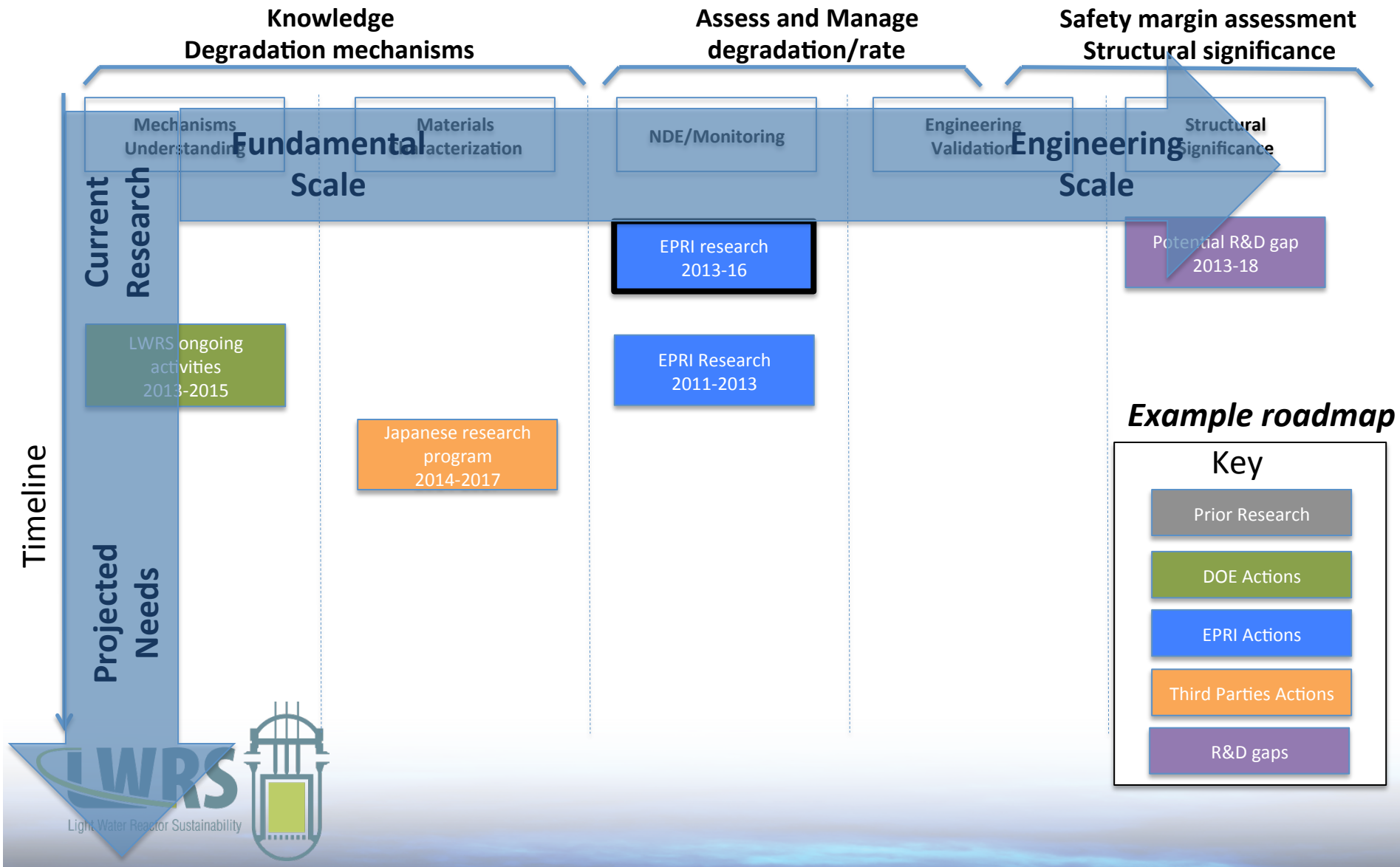
Joint Plan Content

LWRS – Concrete	**Milestones:** • (2013) Complete validation of data contained in the concrete performance database and place database in the public domain. • (2018) Complete concrete and civil infrastructure toolbox development with EPRI and Materials Aging Institute partners. Future milestones and specific tasks will be based on the results of the previous years' testing, as well as ongoing, industry-led research. Completing and publishing a database of concrete performance will yield a high-value tool accessible to all stakeholders. This will allow for more focused research on remaining knowledge gaps and enable more focused material inspections. In the long-term, completion of a concrete and civil structures toolkit may allow for more robust prediction of concrete performance over extended service conditions. These tools are of high value to industry, a partner in their development.
LTO – Comprehensive Aging Management of Concrete Structures	**Milestones**: • (2012) Published report on literature review of radiation damage effects in concrete. • (2013) Initial report on preliminary findings of the effect of irradiation damage on concrete mechanical properties. • (2013) Containment aging pilot plant investigation Outage 2011 and Outage 2012 reports (results of destructive examination/NDE at Ginna and Nine Mile Point); industry guideline(s) for examination of structures for concrete aging. • (2015) Report on experimental study of the effects of boric acid corrosion on concrete. • (2016) Report on radiation damage effects on concrete.

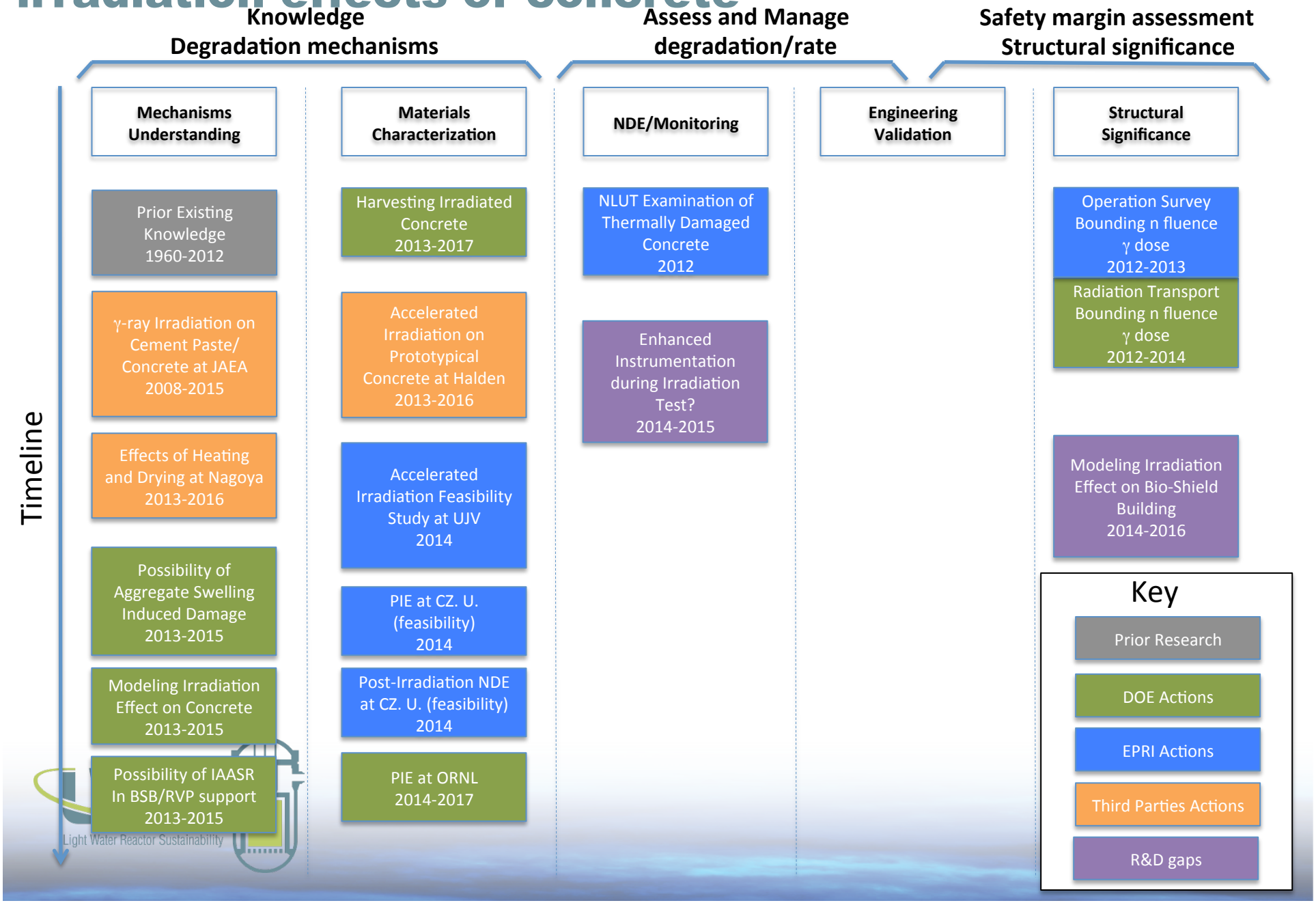
Summary and Action Plan Development

- Concrete aging issues have been identified as an area of research to support LTO
  - Some activities currently underway and planned
- Need to assess completeness of R&D efforts and timing
  - Meeting objective: Develop an initial assessment and plan forward
  - Communicate plan to NRC Division of License Renewal in Dec
  - Maintain and update as appropriate
    - R&D results

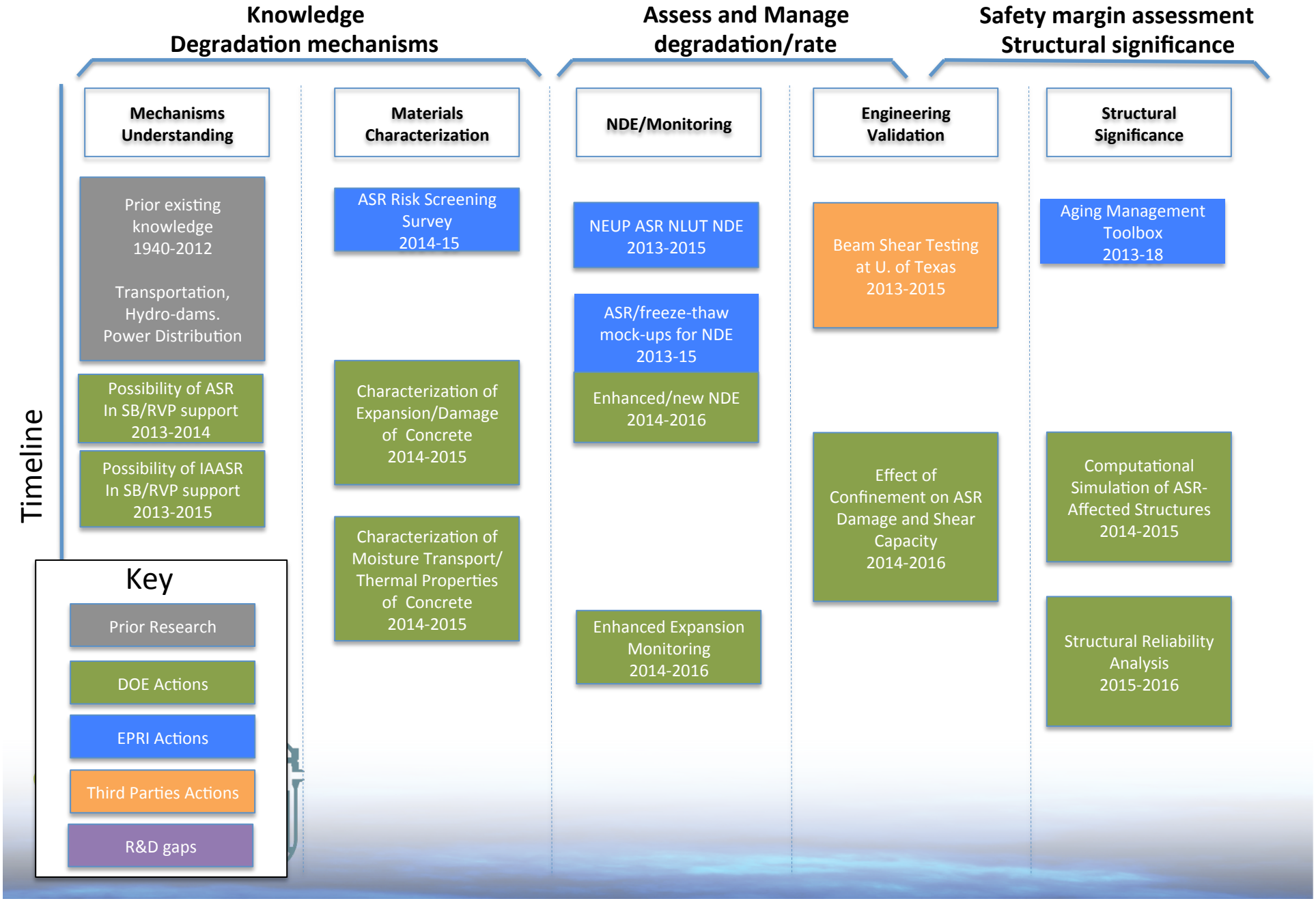
Joint R/D roadmaps have been developed for key research areas



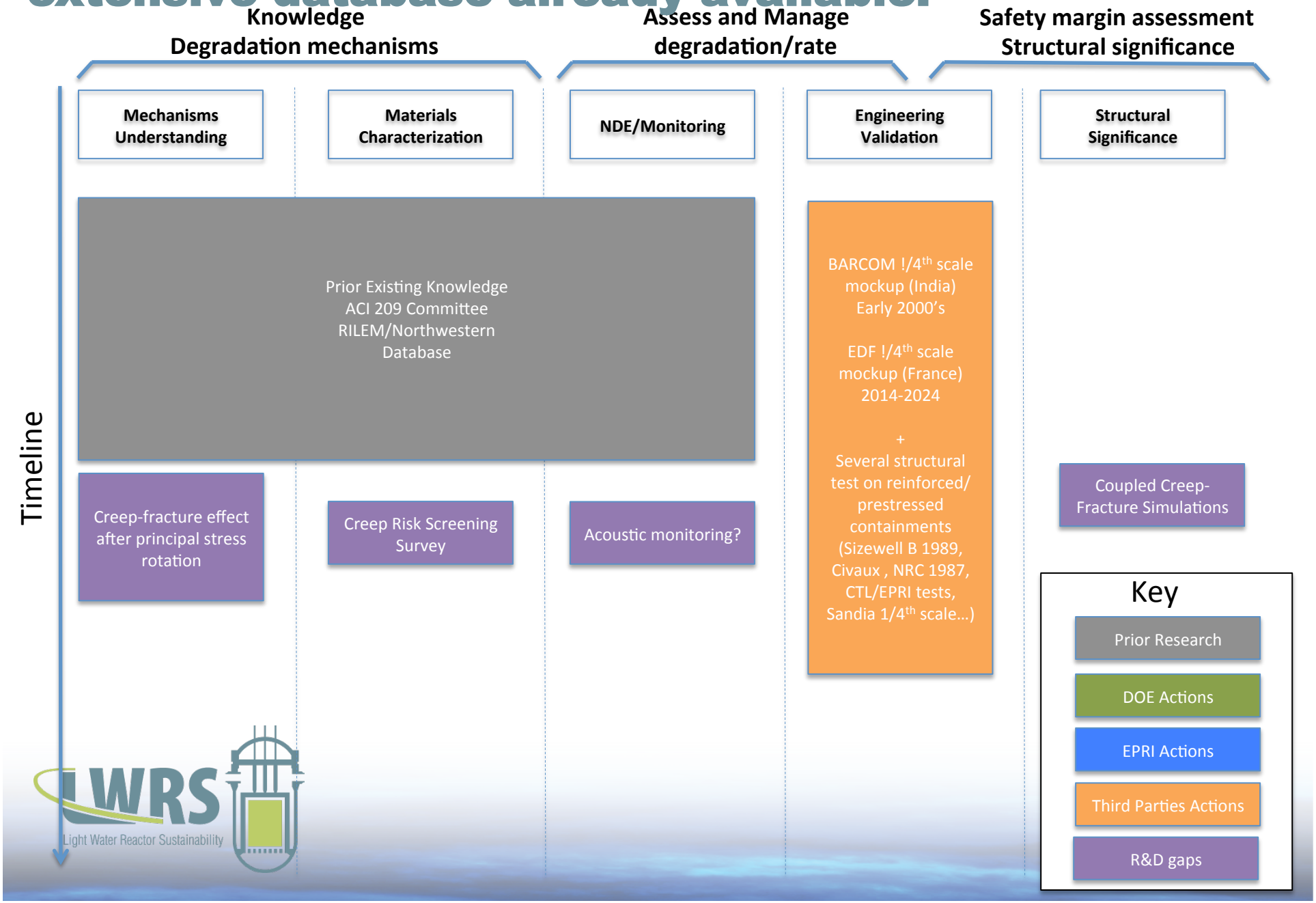
There is considerable research ongoing to support irradiation effects of concrete



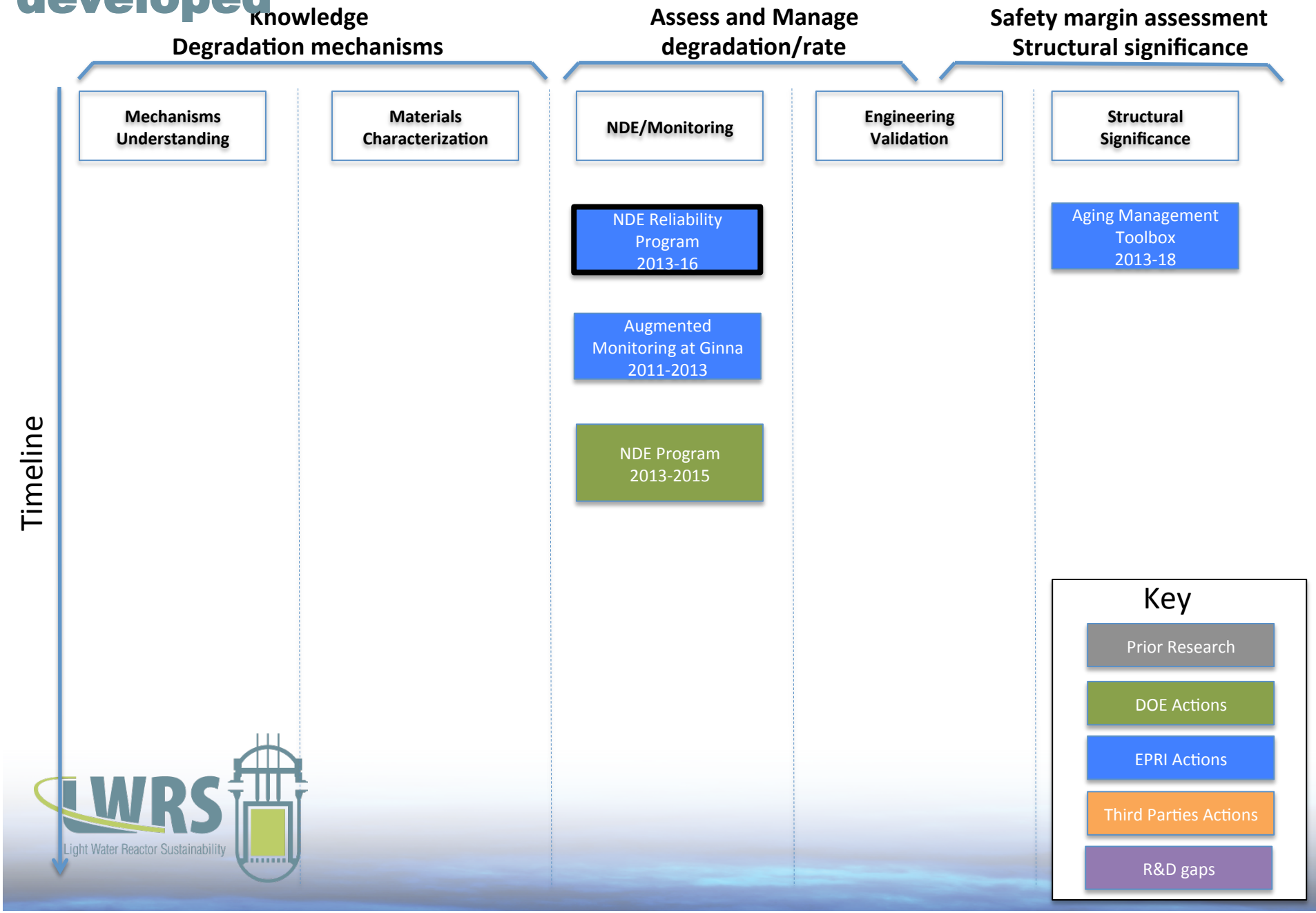
Alkali-Silica Reaction research is also ongoing



Creep/fracture interaction research will rely on the extensive database already available.



Other management tools are also being developed



Summary

- Several potential knowledge gaps for concrete and civil structures in the subsequent operating period have been identified.
  - Irradiation effects
  - Alkali silicia/aggregate reactions
  - Creep/fracture mechanisms
- Joint research is underway in these key areas
- Upcoming presentations will provide more detail into these research projects

Discussion?